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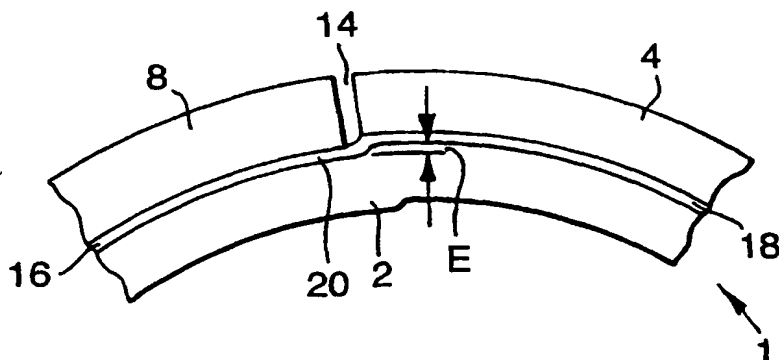
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(54) Title: **MANUFACTURE AND ASSEMBLY OF STRUCTURES**



(57) Abstract: The invention relates to a method of assembling a structure, particularly those structures requiring very tight tolerances. The structure may be assembled by positioning shim material (20) on at least part of a sub-structure (2), curing the shim material (20) in situ, machining the cured shim material (20) to a desired thickness, and then assembling outer layer parts (4, 8) to the sub-structure such that the shim material is situated between the sub-structure and the outer parts. The shim material may be machined to different thicknesses at different locations on the sub-structure, so that, when assembled, the

outer layer parts together conform to a predetermined profile. This is especially advantageous in the manufacture of airframes, where the outer layer panels must provide a smooth surface to avoid unwanted aerodynamic effects.

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MANUFACTURE AND ASSEMBLY OF STRUCTURES

The present invention relates to the manufacture and assembly of structures, particularly those structures having an outer layer or skin secured to or supported by a sub-structure and where the outer layer is required to conform within close tolerances to a predetermined profile.

It is often desirable to assemble such structures by first providing the sub-structure, or skeletal framework, and then attaching panels to the sub-structure to form the outer layer or skin.

This type of structure is common in the design and manufacture of aircraft where light-weight, high strength structures are required. In this industry it is additionally necessary to ensure that all the parts of the structure are manufactured within tight tolerances and furthermore that the parts fit together so that the assembled structure meets stringent accuracy requirements.

Any out of tolerance parts or inaccurately fitted parts will cause the adjacent parts being assembled to be fitted out of their required place in the structure, rendering the structure unacceptable. It is also important that adjacent parts of the outer skin do not have a step between them so that the constituent panels and skins of the outer layer of the aircraft structure are flush with one another. Failing to provide a substantially smooth aircraft outer layer can result in unwanted aerodynamic effects such as increased drag or turbulence.

To meet the strict tolerances required in aircraft construction for example the underlying sub-structure may be made from machinable aluminium or titanium. The sub-structure may then be machined as necessary to allow outer skins or panels to be fitted to it without adjacent skins or panels having a step between them. This method is not desirable as any machining errors may cause the whole sub-structure to fail a quality assurance inspection and be rejected with consequent cost and time penalties. Additionally underlying sub-structures are increasingly being made from lightweight composite materials such as carbon fibre reinforced plastics (CFRP) and these materials are not readily machinable.

A method of producing structures to high accuracy requirements is known, and can be used with sub-structures made of either metal or CFRP. In this

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method, the surfaces of sub-structure to which panels are to be attached are coated with a filled, two component liquid adhesive material, with aluminium added to it. The liquid adhesive is cured on the sub-structure, and is then machined to a desired thickness before the panels or skins are fixed to the sub-structure. The cured adhesive may be machined to different thicknesses at different locations on the sub-structure so that, when the panels or skins are fixed to it there is substantially no step between adjacent panels or skins.

Whilst this method produces structures having profiles with acceptable accuracy, it has several disadvantages. Adhesive of this type is a viscous liquid which must be applied carefully to the sub-structure by hand using a spatula, so that it is distributed reasonably evenly with the desired thickness and without creating air bubbles in the adhesive. Too much adhesive will result in a longer wait for curing and more time spent in machining than necessary. Adhesive of this type is difficult to apply in desired quantities because of its viscosity and furthermore, there are health and safety implications associated with its use. Personnel must be trained to use such adhesive and must be careful when applying it to the sub-structure. Also special tooling must be manufactured, tailor made for each area to be panelled, to prevent the liquid adhesive from spreading to areas where it is not required, and to give guidance as to the thickness of the adhesive being applied. Because of the nature of this type of adhesive, the tooling must be coated with a release agent before use and cleaned thoroughly after use. Repeated exposure to this coating and cleaning process causes the tooling to deteriorate rapidly after a relatively low number of uses, resulting in time lost and expense in manufacturing and fitting replacement tooling.

The present invention seeks to provide a method of assembling structures having an outer layer supported by a sub-structure, and where the outer layer is required to conform, within close tolerances, to a predetermined profile, without the need to machine the sub-structure directly and avoiding the disadvantages of using a two-component liquid adhesive material.

According to the present invention in one aspect thereof, there is provided a method of assembling a structure comprising at least the steps of

providing a sub-structure,

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positioning shim material on at least part of the sub-structure,
curing the shim material disposed on the sub-structure,
machining the cured shim material to a desired thickness, and
assembling an outer layer with the sub-structure such that the shim material lies substantially between the outer layer and the sub-structure.

The shim material is preferably cured at low temperature, at below 80°C for example.

The shim material is advantageously provided pre-formed, for example in the form of a film or a sheet. The film or sheet may be pre-cut so as to be suitable for direct use in particular applications, for example it may be supplied in pre-cut gasket form for use between parts having pre-determined matching dimensions.

The film or sheet may be formed in a range of thicknesses. Alternatively, several layers of shim material may be positioned on the sub-structure to achieve the desired thickness of shim material. Advantageously the shim material has a thickness in the range 0.4 to 4.0 mm.

The shim material preferably is formulated to have sufficient tackiness for allowing it to stick to surfaces on which it is positioned, even if the surfaces are vertical or on the underside of the sub-structure.

The shim material preferably has viscosity such that it substantially does not flow during the heating process up to a cure temperature of 80°C.

Advantageously the shim material is thixotropic, giving minimal flow and slump but being capable of amalgamation at butted joints, at ambient temperatures of between 10°C and 35°C.

The shim material preferably is capable of being stored for several months at -18°C in a stable state such that substantially no curing takes place.

Curing may be effected by exposure of the shim material to ultra violet light or radio frequency radiation.

The outer layer may comprise at least two parts, where each outer layer part is intended to be assembled with the sub-structure and each outer layer part is to be assembled substantially adjacent one or more other outer layer parts.

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The shim material may be machined to different thicknesses at different locations on the sub-structure so that, when assembled to the sub-structure the outer layer parts together conform, within predetermined tolerances, to a predetermined profile. The thickness of each outer layer part is advantageously measured prior to machining the shim material. The desired thickness of the shim material at a given location is dependent upon the thickness of the outer layer part which is to be assembled with the sub-structure at that location.

The shim material preferably comprises at least a resin, a filler and a curing agent. The resin may be any material capable of forming a stable matrix on curing. Suitable resins may be polyesters, urethanes, acrylics, epoxies, vinyl esters or phenolics, for example. Preferably the resin is an epoxy resin. Advantageously the epoxy resin is a Bisphenol A based epoxy resin.

The filler may be an inert material such as talc, calcium carbonate, aluminium silicate, dolomite, alumina trihydrate, wollastonite or glass fibres. In addition the filler may comprise light weight glass microballoons, cenospheres, phenolic microballoons, perlite, hollow ceramic spheres or other plastic spheres. In addition the filler may comprise metallic substances such as aluminium powder, air release agents such as silanes or surfactants, and adhesion promoters such as organosilanes or titanates. The filler is advantageously chosen to be capable of aiding a subsequent machining process.

The shim material preferably comprises a thixotropic agent such as, for example, silicon dioxide, hydrogenated castor oil, sepiolite, bentonite clays, attapulgite clays or diatomaceous earths.

Advantageously the curing agent is a substituted imidazole. Alternatively the curing agent may be an amine, a boron trifluoride complex or a dicyandiamide with a substituted urea accelerator. Preferably the curing agent is 1-methyl imidazole. The curing agent is preferably present at a level of 2 to 10 parts per hundred by weight.

Adhesion improving agents, for example organosilanes, titanates or modified rubbers, may be added to enhance the adhesive quality of the shim material if desired.

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The sheet of shim material may be stored in the freezer until it is required for use.

Embodiments of the invention will now be described, by way of example only, and with reference to the following drawings and examples.

Figure 1 shows an exploded isometric sketch of a sub-structure and parts for assembly into an aircraft structure,

Figure 2 shows a section through a prior art assembly of the sub-structure and parts shown in Figure 1,

Figure 3 shows a section through an assembly of the sub-structure and parts shown in Figure 1 utilising an embodiment of the present invention,

Example 1 describes a material suitable for use as shim material, for example, in the assembly shown in Figure 3, and

Example 2 describes a method of producing the material of Example 1.

Referring now to the drawings in which the same features are denoted by common reference numerals:

Figure 1 shows a structure 1 of part of an aircraft comprising a sub-structure 2 and several outer layer parts 4, 6, 8, 10, 12 to be fitted to the sub-structure 2. The parts and the sub-structure may be formed from metal or carbon fibre composite, as desired. The parts 4, 6, 8, 10, 12 and sub-structure 2 are all manufactured and assembled with adherence to strict tolerance limits.

Figure 2 shows part of the structure 1 comprising parts 4 and 8 which form part of the outer layer of an aircraft. Parts 4 and 8 may be outer skins or detachable panels. Using a prior art method of assembly the parts 4, 8 are fixed to sub-structure 2 with a gap 14 between them. Parts 4, 8 are wet assembled to the substructure 2 using PRC (polysulphide rubber compound) to prevent liquid ingress, the PRC seeping into the gap 14 during assembly. The PRC is applied to the sub-structure before the parts 4 and 8 are assembled to it.

Due to the cumulative dimensional tolerances of the sub-structure and the parts resulting from their individual manufacture, there is a step D between adjacent parts 4 and 8, which results in unwanted aerodynamic effects which can

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affect the performance of the aircraft. For aircraft applications it is typically preferable to have a step D of less than 0.5mm between adjacent parts.

Figure 3 shows part of the same structure 1 comprising parts 4 and 8 which form part of the outer layer of an aircraft structure. As before the parts 4 and 8 may be outer skins or detachable panels and in this example are designed to be of different thicknesses, both panels being within their respective tolerances. The sub-structure 2 is designed to be machined to a profile which is designed to accommodate the different design thicknesses of parts 4 and 8 such that, when assembled, parts 4 and 8 should be substantially flush with one another, so that steps such as D shown in Figure 2 are no greater than 0.5mm. The step E represents the difference in thickness between parts 4 and 8. However, due to variation of the substructure profile, and the cumulative dimensional tolerances of the substructure and the parts 4, 8 a step D would inevitably occur if the prior art method of assembly described above were to be used. However to counter step D, a layer of shim material 20 is introduced between sub-structure 2 and the parts 4 and 8. The shim material is machined to allow parts 4, 8 to be substantially flush when assembled on the substructure, reducing step D to less than 0.5mm.

Using our new method of assembly the layer of shim material 20 of 2mm thickness is stuck to the sub-structure 2. The shim material 20 is formulated to have a tackiness that allows it to stick to surfaces on which it is positioned, even if the surfaces are vertical or on the underside of the sub-structure. The shim material may be cured to a machinable condition at 21°C under atmospheric pressure in 12 hours. Alternatively the shim material may be cured to a machinable condition in 1 hour at 65°C. The heating may be achieved by a hot air gun, using hot rollers, an oven, bank of heaters, a gas thermocatalytic heater or other conventional heating methods.

The shim material substantially does not flow when heated, and so tools for providing boundaries are not required for this method of assembly.

After the shim material 20 is cured, it is machined using conventional machine tools by a desired amount. To determine the desired amount, the actual thicknesses of parts 4 and 8 are first determined and the location on the shim material 20 on which the parts will be positioned is identified. In this example part

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4 is to be positioned at location 18 and part 8 at location 16. The shim material 20 is then machined by differing amounts at locations 18 and 16 respectively, so that the actual profile of the assembly is within tolerance of the datum profile of the assembly. It should be noted that any variations in the surface of the sub-structure 2 or thickness of parts 4 or 8, which might contribute to a step between attached parts 4 and 8, are substantially eliminated by the application of the shim material 20 and its subsequent precision machining.

The shim material 20 is kept in a freezer to prevent curing until it is required for use.

The shim material does not chemically react or otherwise interfere with sealant, such as cured PRC or a cured two part adhesive material, used as a filler to fill cracks and voids in the substructure.

The shim material is self-amalgamating, i.e. when strips of shim material are laid side by side adjacent each other they coalesce. Self amalgamation is temperature and time dependent and preferably occurs within 1 hour at 65°C. The flow characteristics of the shim material may be altered by varying the relative amounts of ingredients.

A material suitable for use as a shimming material, and which may be used in the method described with reference to Figure 3 is a thixotropic filled resin material with a specifically controlled tack which allows strong adherence to vertical or inverted surfaces and facilitates full wetting of the substructure without air entrainment, the filled resin material incorporating a curing agent. An example of such material is as follows

EXAMPLE 1	
Ingredient	Parts by Weight
Bisphenol A based epoxy resin	100
Talc filler	40
Hollow glass microspheres	25
Fumed silica (thixotropic agent)	6
Aluminium powder	5
Air release agent	0.5

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1 – Methyl imidazole (curing agent)	6
Adhesion Improving Agent (Organosilane)	0.1

An example of a method for producing the material described in Example 1 will now be described by way of example only.

Example 2

Pre-heat the Bisphenol A epoxy resin to a temperature at which the viscosity is sufficiently lowered for filler to be incorporated. This temperature will be dependent upon the nature of the epoxy resin and the power rating of the mixing equipment, and will be typically approximately 120-160°C.

Add in the talc filler, heat in a vacuum to degas the mixture and stir.

Add in the glass spheres, degas the mixture and stir.

Add in the air release agent, the adhesion improving agent and the aluminium powder and degas the mixture.

Add in the fumed silica.

Cool the mixture to below 60°C (preferably to 48°C) and degas.

Add the curing agent.

Discharge the mixture, a rollable dough-like substance, on to film forming equipment such as a reverse roll coater, knife over roller coater, extruder or conveyor press.

Form film of desired thickness, incorporating a supporting scrim material if required, and keep the shim material at refrigerated temperatures to prevent curing, until the shim material is required for use.

The shim material may be supplied in suitable lengths of material of selectable starting thickness, or it may be supplied in the form of pre-cut "gaskets" designed to fit the surfaces of the sub-structure to accommodate panels of various shapes. It should be curable at 65° and have a useable life out of refrigeration of at least 12 hours. The scrim material improves the fatigue life of the shim material, and strengthens the shim material. The scrim material ideally weighs 10-50 g/m².

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and is incorporated into one side of the film during manufacture of the shim material. The scrim material is preferably brightly coloured so that an operator can see which side of the film incorporates the scrim material and use it as a 'witness' mark during machining of the shim. During use, it is advantageous to position the film such that the supporting scrim material is adjacent the sub-structure and so does not get machined away following curing of the shim material.

It will now be apparent to one skilled in the art that characteristics of the shim material may be altered to suit different applications by changing the relative amounts of ingredients. For example, to alter flow characteristics or adhesive characteristics the ratio of filler to resin may be varied. As another example, the density of the shim material may be altered by varying the amounts of different filler materials relative to each other.

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CLAIMS

1. A method of assembling a structure comprising at least the steps of:
providing a sub-structure,
positioning shim material on at least part of the sub-structure,
curing the shim material disposed on the sub-structure,
machining the cured shim material to a desired thickness, and
assembling an outer layer with the sub-structure such that the shim material lies substantially between the outer layer and the sub-structure.
2. A method as claimed in claim 1 wherein the shim material is cured at below 80°C.
3. A method as claimed in any preceding claim wherein the curing is effected by exposure of the shim material to ultra violet light.
4. A method as claimed in claim 1 or claim 2 wherein the curing is effected by exposure of the shim material to radio frequency radiation.
5. A method as claimed in any preceding claim wherein the outer layer comprises at least two parts and the thickness of each outer layer part is measured prior to machining the shim material.
6. A method as claimed in claim 5 wherein the shim material is machined to different thicknesses at different locations on the sub-structure so that, when assembled to the sub-structure, the outer layer parts together conform, within pre-determined tolerances, to a pre-determined profile.
7. A method as claimed in any of claims 1 to 6 wherein the shim material is pre-formed into a film or sheet prior to its being positioned on the sub-structure.
8. A method as claimed in claim 7 wherein the film or sheet of shim material is pre-cut into a shape suitable for direct use in a particular application prior to the shim material being positioned on the sub-structure.
9. A method as claimed in claim 7 or claim 8 wherein the film or sheet of shim material has a thickness in the range 0.4 to 4.0 mm.

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10. A method as claimed in any preceding claim wherein the shim material is positioned on a vertical surface of the sub-structure.
11. A method as claimed in any of claims 1 to 9 wherein the shim material is positioned on the underside of the sub-structure.
12. A method as claimed in any preceding claim wherein the shim material substantially does not flow during curing at temperatures of up to 80°C.

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Fig.1.

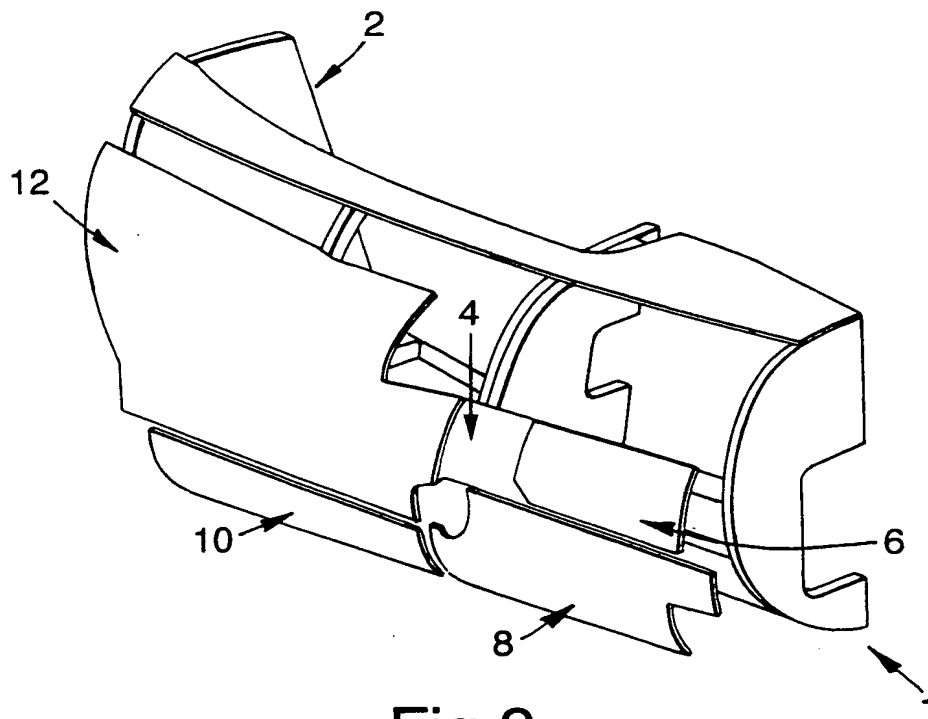


Fig.2.

PRIOR ART

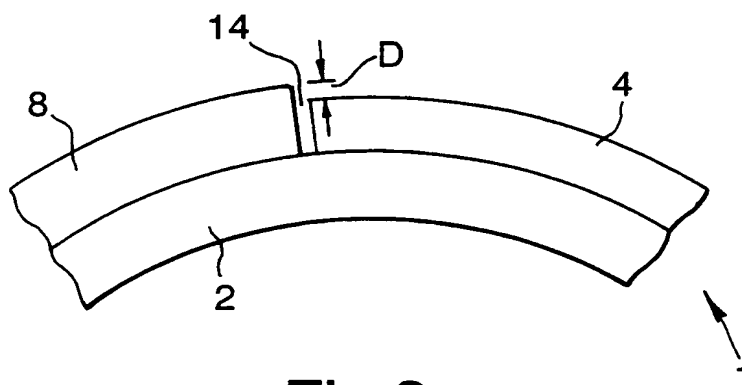
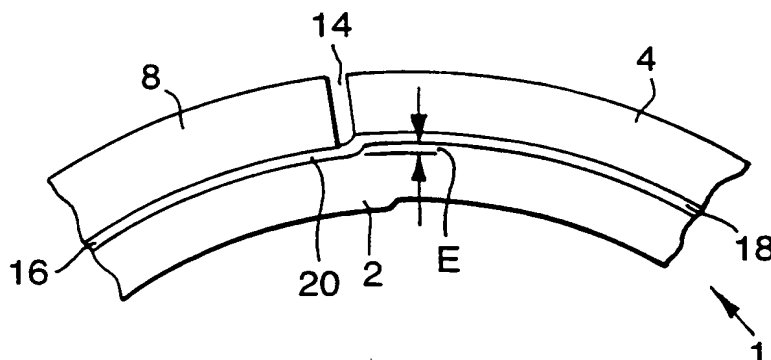


Fig.3.



PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
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in its capacity as elected Office

Date of mailing (day/month/year) 02 May 2001 (02.05.01)	
International application No. PCT/GB00/03165	Applicant's or agent's file reference XA1255
International filing date (day/month/year) 16 August 2000 (16.08.00)	Priority date (day/month/year) 21 August 1999 (21.08.99)
Applicant FISHER, David et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
23 February 2001 (23.02.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<p>The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland</p> <p>Facsimile No.: (41-22) 740.14.35</p>	<p>Authorized officer S. Mafla</p> <p>Telephone No.: (41-22) 338.83.38</p>
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PATENT COOPERATION TREATY

PCT

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

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IPC 3700

Applicant's or agent's file reference XA1255		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/03165	International filing date (day/month/year) 16/08/2000	Priority date (day/month/year) 21/08/1999	
International Patent Classification (IPC) or national classification and IPC B64C1/12			
Applicant BAE SYSTEM plc			



1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 23/02/2001	Date of completion of this report 20.11.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Silva d'Oliveira, M Telephone No. +49 89 2399 7376 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03165

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-9 as originally filed

Claims, No.:

1-12 as originally filed

Drawings, sheets:

1/1 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03165

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 3-4, 7-9
	No:	Claims 1-2, 5-6, 10-12
Inventive step (IS)	Yes:	Claims
	No:	Claims 3-4, 7-9
Industrial applicability (IA)	Yes:	Claims 1-12
	No:	Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The document US 3 609 116(=D1) is regarded as being the closest prior art to the subject-matter of claim 1, and discloses (the references in parentheses applying to this document):

A method of assembling a structure comprising at least the steps of:
providing a sub-structure, positioning shim material(120, 230, 350, 338) on at least part of the sub-structure, curing the shim material disposed on the sub-structure, machining the cured shim material to a desired thickness, and assembling an outer layer with the sub-structure such that the shim material lies substantially between the outer layer and the sub-structure (see Fig. 1-3, column 1, lines 74-column 2, line 30 and column 6, lines 57-column 7, line 46).

Since D1 includes all the features of claim 1, the subject-matter of independent claim 1 is not novel (Article 33(1)-(2) PCT).

2. Dependent claims 2, 5, 6 and 10 to 12 are already known from D1. Therefore, the subject-matter of claims 2, 5, 6 and 10 to 12 is not novel (Article 33(2) PCT).
3. The curing by exposure of the shim material to ultra violet light or to radio frequency radiation is well known in the art. Therefore the additional features of claims 3 and 4 do not result in an inventive step when added to claim 1 (Article 33(3) PCT).
4. The pre-forming of the shim material into a film or sheet, as well as the pre-cutting of the film or sheet of shim material into a suitable shape, prior to its positioning on the sub-structure are also well known in the art. Therefore the additional features of claims 7 to 9 do not result in an inventive step when added to claim 1 (Article 33(3) PCT).

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03165

Re Item VII

Certain defects in the international application

1. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
2. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference XA1255	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 03165	International filing date (day/month/year) 16/08/2000	(Earliest) Priority Date (day/month/year) 21/08/1999
Applicant BAE SYSTEM plc		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of Invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☒ because this figure better characterizes the invention.

3
☐ None of the figures.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/GB 00/ 03165

Box III TEXT OF THE ABSTRACT (Continuation of Item 5 of the first sheet)

It is to be added references in parentheses as follows:

- line 3: ... shim material (20)... sub-structure (2), ...
- line 4: material (20)... shim material (20)...
- line 5: ... outer layer parts (4, 8)...

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/03165

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B64C1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B64C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 609 116 A (THOMAS JACK E ET AL) 28 September 1971 (1971-09-28) column 6, line 57 -column 7, line 46 ---	1-6, 10
A	US 4 478 915 A (POSS ELIASZ ET AL) 23 October 1984 (1984-10-23) claims ---	1-12
A	US 4 861 643 A (SCOLLARD CYNTHIA M) 29 August 1989 (1989-08-29) claims -----	1-12

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

26 October 2000

Date of mailing of the international search report

08/11/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Van Wallene, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/03165

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3609116	A	28-09-1971	NONE	
US 4478915	A	23-10-1984	BR 8405632 A	10-09-1985
			CA 1245888 A	06-12-1988
			DE 3440360 A	15-05-1985
			ES 537398 D	16-05-1986
			ES 8606934 A	16-10-1986
			IT 1178622 B	09-09-1987
US 4861643	A	29-08-1989	US 4980005 A	25-12-1990



Application No: GB 9919787.3
Claims searched: 1 to 7

Examiner: R.J.MIRAMS
Date of search: 5 November 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.Q): B5N, B7W.
Int Cl (Ed.6): B29C. B32B 31/00, 31/12. B64C 1/12, 3/26.
Other: ONLINE: WPI, EPODOC, JAPIO.

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US5385050A (Roberts)	
A	US4861643A (Scollard)	

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family

A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 6661

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 3 609 116 A (THOMAS JACK E ET AL) 28 September 1971 (1971-09-28) * column 6, line 57 - column 7, line 46 *	1-10	B64C1/12
A	US 4 478 915 A (POSS ELIASZ ET AL) 23 October 1984 (1984-10-23) * claims *	1-10	
A	US 4 861 643 A (SCOLLARD CYNTHIA M) 29 August 1989 (1989-08-29) * claims *	1-10	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			B64C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 1 February 2000	Examiner Van Wallene, A
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 30 6661

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

01-02-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3609116 A	28-09-1971	NONE	
US 4478915 A	23-10-1984	BR 8405632 A	10-09-1985
		CA 1245888 A	06-12-1988
		DE 3440360 A	15-05-1985
		ES 537398 A	16-05-1986
		IT 1178622 B	09-09-1987
US 4861643 A	29-08-1989	US 4980005 A	25-12-1990

CT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty

For receiving Office use only	
International Application No	
International Filing Date	
Name of receiving Office and "PCT International Application"	
Applicant's or agent's file reference (if desired) (12 characters maximum) XA1255	

Box No I TITLE OF INVENTION	
MANUFACTURE AND ASSEMBLY OF STRUCTURES	
Box No II APPLICANT	
Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below BAE SYSTEMS plc Warwick House P O Box 87 Farnborough Aerospace Centre Farnborough, Hampshire GU14 6YU, United Kingdom	
<input type="checkbox"/> This person is also inventor	
Telephone No 01252 384628	
Facsimile No 01252 383091	
Teleprinter No	
State (that is, country) of nationality: GB	State (that is, country) of residence: GB
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
Box No III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below Advanced Composites Group Ltd Composites House Adams Close Heanor Gate Industrial Estate Heanor, Derbyshire DE75 7SW, United Kingdom	
This person is: <input checked="" type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below)	
State (that is, country) of nationality: GB	State (that is, country) of residence: GB
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet	
Box No IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: <input checked="" type="checkbox"/> agent <input type="checkbox"/> common representative	
Name and address: (Family name followed by given name; for a legal entity, full official designation) The address must include postal code and name of country WILDMAN, David, Brian BAE SYSTEMS plc Group IP Department Lancaster House, P.O. Box 87 Farnborough Aerospace Centre Farnborough, Hampshire, GU14 6YU United Kingdom	
Telephone No 01252 384623	
Facsimile No 01252 383091	
Teleprinter No	
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent	

Continuation of Box No. ☐ **FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)***If none of the following sub-boxes is used, this sheet should not be included in the request* ☐

Name and address: (Family name followed by given name; for a legal entity, full official designation) ☐ The address must include postal code and name of country ☐ The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below ☐

FISHER, David
20 Hardhorn Way
Poulton-le-Fylde
Lancashire
FY6 8AE
United Kingdom

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only (If this check-box is marked, do not fill in below) ☐

State (that is, country) of nationality:
GB

State (that is, country) of residence:
GB

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation) ☐ The address must include postal code and name of country ☐ The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below ☐

RUTHERFORD, Alan, Leslie
46 Captains Lane
Barton-Under-Needwood
Staffordshire
DE13 3EZ
United Kingdom

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only (If this check-box is marked, do not fill in below) ☐

State (that is, country) of nationality:
GB

State (that is, country) of residence:
GB

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation) ☐ The address must include postal code and name of country ☐ The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below ☐

This person is:

- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only (If this check-box is marked, do not fill in below) ☐

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation) ☐ The address must include postal code and name of country ☐ The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below ☐

This person is:

- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only (If this check-box is marked, do not fill in below) ☐

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet ☐

Box No.V DESIGNATION OF STATES

The following designation is hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

- ☒ **AP** ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, MZ Mozambique, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | |
|---|---|
| <input checked="" type="checkbox"/> AE United Arab Emirates | <input checked="" type="checkbox"/> LC Saint Lucia |
| <input checked="" type="checkbox"/> AG Antigua and Barbuda | <input checked="" type="checkbox"/> LK Sri Lanka |
| <input checked="" type="checkbox"/> AL Albania | <input checked="" type="checkbox"/> LR Liberia |
| <input checked="" type="checkbox"/> AM Armenia | <input checked="" type="checkbox"/> LS Lesotho |
| <input checked="" type="checkbox"/> AT Austria | <input checked="" type="checkbox"/> LT Lithuania |
| <input checked="" type="checkbox"/> AU Australia | <input checked="" type="checkbox"/> LU Luxembourg |
| <input checked="" type="checkbox"/> AZ Azerbaijan | <input checked="" type="checkbox"/> LV Latvia |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina | <input checked="" type="checkbox"/> MA Morocco |
| <input checked="" type="checkbox"/> BB Barbados | <input checked="" type="checkbox"/> MD Republic of Moldova |
| <input checked="" type="checkbox"/> BG Bulgaria | <input checked="" type="checkbox"/> MG Madagascar |
| <input checked="" type="checkbox"/> BR Brazil | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input checked="" type="checkbox"/> BY Belarus | <input checked="" type="checkbox"/> MN Mongolia |
| <input checked="" type="checkbox"/> BZ Belize | <input checked="" type="checkbox"/> MW Malawi |
| <input checked="" type="checkbox"/> CA Canada | <input checked="" type="checkbox"/> MX Mexico |
| <input checked="" type="checkbox"/> CH and LI Switzerland and Liechtenstein | <input checked="" type="checkbox"/> MZ Mozambique |
| <input checked="" type="checkbox"/> CN China | <input checked="" type="checkbox"/> NO Norway |
| <input checked="" type="checkbox"/> CR Costa Rica | <input checked="" type="checkbox"/> NZ New Zealand |
| <input checked="" type="checkbox"/> CU Cuba | <input checked="" type="checkbox"/> PL Poland |
| <input checked="" type="checkbox"/> CZ Czech Republic | <input checked="" type="checkbox"/> PT Portugal |
| <input checked="" type="checkbox"/> DE Germany | <input checked="" type="checkbox"/> RO Romania |
| <input checked="" type="checkbox"/> DK Denmark | <input checked="" type="checkbox"/> RU Russian Federation |
| <input checked="" type="checkbox"/> DM Dominica | <input checked="" type="checkbox"/> SD Sudan |
| <input checked="" type="checkbox"/> DZ Algeria | <input checked="" type="checkbox"/> SE Sweden |
| <input checked="" type="checkbox"/> EE Estonia | <input checked="" type="checkbox"/> SG Singapore |
| <input checked="" type="checkbox"/> ES Spain | <input checked="" type="checkbox"/> SI Slovenia |
| <input checked="" type="checkbox"/> FI Finland | <input checked="" type="checkbox"/> SK Slovakia |
| <input checked="" type="checkbox"/> GB United Kingdom | <input checked="" type="checkbox"/> SL Sierra Leone |
| <input checked="" type="checkbox"/> GD Grenada | <input checked="" type="checkbox"/> TJ Tajikistan |
| <input checked="" type="checkbox"/> GE Georgia | <input checked="" type="checkbox"/> TM Turkmenistan |
| <input checked="" type="checkbox"/> GH Ghana | <input checked="" type="checkbox"/> TR Turkey |
| <input checked="" type="checkbox"/> GM Gambia | <input checked="" type="checkbox"/> TT Trinidad and Tobago |
| <input checked="" type="checkbox"/> HR Croatia | <input checked="" type="checkbox"/> TZ United Republic of Tanzania |
| <input checked="" type="checkbox"/> HU Hungary | <input checked="" type="checkbox"/> UA Ukraine |
| <input checked="" type="checkbox"/> ID Indonesia | <input checked="" type="checkbox"/> UG Uganda |
| <input checked="" type="checkbox"/> IL Israel | <input checked="" type="checkbox"/> US United States of America |
| <input checked="" type="checkbox"/> IN India | <input checked="" type="checkbox"/> UZ Uzbekistan |
| <input checked="" type="checkbox"/> IS Iceland | <input checked="" type="checkbox"/> VN Viet Nam |
| <input checked="" type="checkbox"/> JP Japan | <input checked="" type="checkbox"/> YU Yugoslavia |
| <input checked="" type="checkbox"/> KE Kenya | <input checked="" type="checkbox"/> ZA South Africa |
| <input checked="" type="checkbox"/> KG Kyrgyzstan | <input checked="" type="checkbox"/> ZW Zimbabwe |
| <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea | <input type="checkbox"/> Check-box reserved for designating States which have become party to the PCT after issuance of this sheet: |
| <input checked="" type="checkbox"/> KR Republic of Korea | |
| <input checked="" type="checkbox"/> KZ Kazakhstan | |

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

Box No. VI PRIORITY CLAIM

☐ Further priority claims are indicated in the Supplemental Box

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application: regional Office	international application: receiving Office
item (1) 21 AUGUST 1999	9919787.3	GB		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1)

* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 40(b)(ii)) See Supplemental Box

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA)
(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year)	Number	Country (or regional Office)
15 February 2000	99306661.2	EP

Box No. VIII CHECK LIST: LANGUAGE OF FILING

This international application contains the following number of sheets:

request : 04
description (excluding sequence listing part) : 09
claims : 02
abstract : 01
drawings : 02
sequence listing part of description : -

Total number of sheets : 18

This international application is accompanied by the item(s) marked below:

- 1 ☐ fee calculation sheet
2 ☐ separate signed power of attorney
3 ☒ copy of general power of attorney; reference number, if any:
4 ☐ statement explaining lack of signature
5 ☐ priority document(s) identified in Box No. VI as item(s):
6 ☐ translation of international application into (language):
7 ☐ separate indications concerning deposited microorganism or other biological material
8 ☐ nucleotide and/or amino acid sequence listing in computer readable form
9 ☒ other (specify): GB FORM 23/77 REQUEST CERTIFIED COPY

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: ENGLISH

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request)



WILDMAN, David, Brian

For receiving Office use only

1 <input type="checkbox"/> Date of actual receipt of the purported international application:	2 <input type="checkbox"/> Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received:
3 <input type="checkbox"/> Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4 <input type="checkbox"/> Date of timely receipt of the required corrections under PCT Article 11(2):	
5 <input type="checkbox"/> International Searching Authority (if two or more are competent): ISA /	6 <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau: